Code No: R05322104 **R05** **Set No. 2**

III B.Tech II Semester Examinations,APRIL 2011
COMPUTATIONAL AERODYNAMICS
Aeronautical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) What is Computational Fluid Dynamics? Explain with any two examples its applications in industrial manufacturing industry.
   (b) Explain with diagrams the flow models that use finite control volume approach and infinitesimal fluid element approach. [8+8]

2. What are the available structured grid generation techniques and explain the conformal mapping method. [16]

3. (a) Why computational fluid dynamics makes a distinction between conservation and non-conservation forms of governing equations? Explain with examples.
   (b) Explain why conservation form of governing equations is important for calculations using shock capturing method with the help of an example of flow across a normal shock wave. [8+8]

4. Prove that an expression for second-order central difference expression for the mixed derivative is $\left(\frac{\partial^2 u}{\partial x \partial y}\right)_{i,j} = \frac{u_{i+1,j+1}-u_{i+1,j-1}-u_{i-1,j+1}+u_{i-1,j-1}}{4\Delta x \Delta y} + O\left[(\Delta x)^2, (\Delta y)^2\right]$ can be obtained. [16]

5. (a) What is grid adaption
   (b) Its need in a flow domain.
   (c) Role played by it on the numerical solution with an example for two dimensional steady flow in a pipe. [4+4+8]

6. (a) Derive the continuity equation $\partial\rho/\partial t + \nabla \bullet (\rho V) = 0$ assuming appropriate flow model.
   (b) Derive the continuity equation $D\rho/Dt + \rho\nabla \bullet \nabla = 0$ assuming appropriate flow model. [8+8]

7. Classify the following partial differential equations according to their nature as elliptic/parabolic or hyperbolic

   (a) Unsteady Thermal Conduction Equation: $\partial T/\partial t = \alpha\partial^2 T/\partial t^2$
   (b) Laplace's Equation: $\partial^2\phi/\partial x^2 + \partial^2\phi/\partial y^2 = 0$
   (c) Second-order wave equation: $\partial^2 u/\partial t^2 = c^2\partial^2 u/\partial x^2$
   (d) First - order wave equation: $\partial u/\partial t + c\partial u/\partial x = 0$. [4+4+4+4]

8. What are metrics and derive the relationship between the direct and inverse metrics. [16]

$$i.e. \quad \begin{array}{ll} \frac{\partial \xi}{\partial x} = \frac{1}{J} \frac{\partial y}{\partial \eta} & \frac{\partial \eta}{\partial x} = -\frac{1}{J} \frac{\partial y}{\partial \xi} \\ \frac{\partial \xi}{\partial y} = -\frac{1}{J} \frac{\partial x}{\partial \eta} & \frac{\partial \eta}{\partial y} = \frac{1}{J} \frac{\partial x}{\partial \xi} \end{array}$$

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Code No: R05322104 **R05** **Set No. 4**

III B.Tech II Semester Examinations,APRIL 2011
COMPUTATIONAL AERODYNAMICS
Aeronautical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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1. Prove that an expression for second-order central difference expression for the mixed derivative is $\left(\frac{\partial^2 u}{\partial x \partial y}\right)_{i,j} = \frac{u_{i+1,j+1} - u_{i+1,j-1} - u_{i-1,j+1} + u_{i-1,j-1}}{4\Delta x \Delta y} + O\left[(\Delta x)^2, (\Delta y)^2\right]$ can be obtained. [16]

2. Classify the following partial differential equations according to their nature as elliptic/parabolic or hyperbolic
   (a) Unsteady Thermal Conduction Equation: $\partial T/\partial t = \alpha \partial^2 T/\partial t^2$
   (b) Laplace's Equation: $\partial^2 \phi/\partial x^2 + \partial^2 \phi/\partial y^2 = 0$
   (c) Second-order wave equation: $\partial^2 u/\partial t^2 = c^2 \partial^2 u/\partial x^2$
   (d) First - order wave equation: $\partial u/\partial t + c\partial u/\partial x = 0$. [4+4+4+4]

3. (a) Why computational fluid dynamics makes a distinction between conservation and non-conservation forms of governing equations? Explain with examples.
   (b) Explain why conservation form of governing equations is important for calculations using shock capturing method with the help of an example of flow across a normal shock wave. [8+8]

4. (a) What is Computational Fluid Dynamics? Explain with any two examples its applications in industrial manufacturing industry.
   (b) Explain with diagrams the flow models that use finite control volume approach and infinitesimal fluid element approach. [8+8]

5. (a) What is grid adaption
   (b) Its need in a flow domain.
   (c) Role played by it on the numerical solution with an example for two dimensional steady flow in a pipe. [4+4+8]

6. (a) Derive the continuity equation $\partial\rho/\partial t + \nabla \bullet (\rho V) = 0$ assuming appropriate flow model.
   (b) Derive the continuity equation $D\rho/Dt + \rho\nabla \bullet \nabla = 0$ assuming appropriate flow model. [8+8]

7. What are the available structured grid generation techniques and explain the conformal mapping method. [16]

8. What are metrics and derive the relationship between the direct and inverse metrics. [16]

$$i.e.\quad \begin{array}{ll} \frac{\partial \xi}{\partial x} = \frac{1}{J}\ \frac{\partial y}{\partial \eta} & \frac{\partial \eta}{\partial x} = -\frac{1}{J}\ \frac{\partial y}{\partial \xi} \\ \frac{\partial \xi}{\partial y} = -\frac{1}{J}\ \frac{\partial x}{\partial \eta} & \frac{\partial \eta}{\partial y} = \frac{1}{J}\ \frac{\partial x}{\partial \xi} \end{array}$$

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Code No: R05322104 **R05** **Set No. 1**

III B.Tech II Semester Examinations,APRIL 2011
COMPUTATIONAL AERODYNAMICS
Aeronautical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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1. What are metrics and derive the relationship between the direct and inverse metrics. [16]

$$i.e. \quad \begin{matrix} \frac{\partial\xi}{\partial x} = \frac{1}{J}\ \frac{\partial y}{\partial \eta} & \frac{\partial\eta}{\partial x} = -\frac{1}{J}\ \frac{\partial y}{\partial \xi} \\ \frac{\partial\xi}{\partial y} = -\frac{1}{J}\ \frac{\partial x}{\partial \eta} & \frac{\partial\eta}{\partial y} = \frac{1}{J}\ \frac{\partial x}{\partial \xi} \end{matrix}$$

2. What are the available structured grid generation techniques and explain the conformal mapping method. [16]

3. (a) What is Computational Fluid Dynamics? Explain with any two examples its applications in industrial manufacturing industry.
   (b) Explain with diagrams the flow models that use finite control volume approach and infinitesimal fluid element approach. [8+8]

4. (a) Why computational fluid dynamics makes a distinction between conservation and non-conservation forms of governing equations? Explain with examples.
   (b) Explain why conservation form of governing equations is important for calculations using shock capturing method with the help of an example of flow across a normal shock wave. [8+8]

5. (a) What is grid adaption
   (b) Its need in a flow domain.
   (c) Role played by it on the numerical solution with an example for two dimensional steady flow in a pipe. [4+4+8]

6. Prove that an expression for second-order central difference expression for the mixed derivative is $\left(\frac{\partial^2 u}{\partial x \partial y}\right)_{i,j} = \frac{u_{i+1,j+1} - u_{i+1,j-1} - u_{i-1,j+1} + u_{i-1,j-1}}{4\Delta x \Delta y} + O\left[(\Delta x)^2, (\Delta y)^2\right]$ can be obtained. [16]

7. (a) Derive the continuity equation $\partial\rho/\partial t + \nabla \bullet (\rho V) = 0$ assuming appropriate flow model.
   (b) Derive the continuity equation $D\rho/Dt + \rho\nabla \bullet \nabla = 0$ assuming appropriate flow model. [8+8]

8. Classify the following partial differential equations according to their nature as elliptic/parabolic or hyperbolic

(a) Unsteady Thermal Conduction Equation: $\partial T/\partial t = \alpha \partial^2 T/\partial t^2$

(b) Laplace's Equation: $\partial^2 \phi/\partial x^2 + \partial^2 \phi/\partial y^2 = 0$

(c) Second-order wave equation: $\partial^2 u/\partial t^2 = c^2 \partial^2 u/\partial x^2$

(d) First - order wave equation: $\partial u/\partial t + c\partial u/\partial x = 0$. [4+4+4+4]

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Code No: R05322104 **R05** **Set No. 3**

III B.Tech II Semester Examinations,APRIL 2011
COMPUTATIONAL AERODYNAMICS
Aeronautical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Derive the continuity equation $\partial\rho/\partial t + \nabla \bullet (\rho V) = 0$ assuming appropriate flow model.
   (b) Derive the continuity equation $D\rho/Dt + \rho\nabla \bullet \nabla = 0$ assuming appropriate flow model. [8+8]

2. What are metrics and derive the relationship between the direct and inverse metrics. [16]

$$i.e. \quad \begin{matrix} \frac{\partial\xi}{\partial x} = \frac{1}{J}\ \frac{\partial y}{\partial \eta} & \frac{\partial\eta}{\partial x} = -\frac{1}{J}\ \frac{\partial y}{\partial \xi} \\ \frac{\partial\xi}{\partial y} = -\frac{1}{J}\ \frac{\partial x}{\partial \eta} & \frac{\partial\eta}{\partial y} = \frac{1}{J}\ \frac{\partial x}{\partial \xi} \end{matrix}$$

3. (a) What is Computational Fluid Dynamics? Explain with any two examples its applications in industrial manufacturing industry.
   (b) Explain with diagrams the flow models that use finite control volume approach and infinitesimal fluid element approach. [8+8]

4. Prove that an expression for second-order central difference expression for the mixed derivative is $\left(\frac{\partial^2 u}{\partial x \partial y}\right)_{i,j} = \frac{u_{i+1,j+1} - u_{i+1,j-1} - u_{i-1,j+1} + u_{i-1,j-1}}{4\Delta x \Delta y} + O\left[(\Delta x)^2, (\Delta y)^2\right]$ can be obtained. [16]

5. What are the available structured grid generation techniques and explain the conformal mapping method. [16]

6. Classify the following partial differential equations according to their nature as elliptic/parabolic or hyperbolic

   (a) Unsteady Thermal Conduction Equation: $\partial T/\partial t = \alpha\partial^2 T/\partial t^2$
   (b) Laplace's Equation: $\partial^2\phi/\partial x^2 + \partial^2\phi/\partial y^2 = 0$
   (c) Second-order wave equation: $\partial^2 u/\partial t^2 = c^2\partial^2 u/\partial x^2$
   (d) First - order wave equation: $\partial u/\partial t + c\partial u/\partial x = 0$. [4+4+4+4]

7. (a) Why computational fluid dynamics makes a distinction between conservation and non-conservation forms of governing equations? Explain with examples.
   (b) Explain why conservation form of governing equations is important for calculations using shock capturing method with the help of an example of flow across a normal shock wave. [8+8]

8. (a) What is grid adaption
   (b) Its need in a flow domain.
   (c) Role played by it on the numerical solution with an example for two dimensional steady flow in a pipe. [4+4+8]

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